Reducing Energy Costs for the Pasteurization of Corn and Wheat Straw Bales for Producing Mushrooms in Mexico with a Solar Oven made with Recycled Materials

J. Domínguez-Aldana[1], H.E. Ruelas-Monroy[2], V.D. Hernández-Bello[3,]
J.C. González-Castillo[4], I. Ruiz-González[5], L. Paniagua-Sánchez[6]

It is well known that adaptation to climate change requires an interdisciplinary engineering approach and agricultural solutions depends on a reliable use of energy. Therefore mechatronics and industrial engineers in Queretaro, Mexico designed a solar oven in order to reduce energy consumption for the pasteurization of corn and wheat residues that are used to cultivate mushrooms. In Mexico, mushrooms (*Pleurotus ostreatus*) are an important crop, with around 3031 tons produced annually (Martínez-Carrera et al., 2012). This number reaffirms the importance of analyzing the energy costs for pasteurizing the bale of wheat or corn residue that is used to cultivate mushrooms.

In Mexico the cost of gas for pasteurizing corn and wheat straw was calculated and had a value of $92.47 dollars annually (using a conversion factor of 18.28 Mexican pesos per American dollar, checked on 19/01/2016), based on the production margin available of 3 kg per pasteurization (Flores-Montes-de-Oca and Contreras-Trujano, 2012) and the gas consumption of an average burner. The annual costs for pasteurization based on the national production of Mexico were obtained, giving a result of $94,723.38 dollars.

The design and construction of the solar oven focuses on both reduction of costs and the capacity to harvest mushrooms (*Pleurotus ostreatus*). The team prioritized that all materials to be used were recycled and/or easy to acquire, and the basic structure was formed of MDF (Medium Density Fiberboard), which is an agglomerate made from different wood fibers (mostly pine) that is combined with synthetic resins and high pressure in order to make it stick together. This kind of material was ideal due to its light properties and low cost. The iron used came from a scrap metal yard, and was easily adapted to the project's necessities. Another important component was the glass, which was cut from a section of an old window.

The first step was the investigation and selection of materials for construction, as well as the types of solar collectors that exist. After the selection, which was based on the lowest cost and easiest construction prototype, calculations were made based on the preselected design and theoretical basis. After the calculations, the design was modeled in the SolidWorks design software. With the aid of the software, a very precise material optimization could be achieved, and it was also useful in visualizing the dimensions of the solar furnace (Figure 1).

The construction of the first prototype took about 1.5 months, and had a total cost of $80. The results obtained indicated that a temperature of 82°C could be achieved in 55 minutes with an incident solar radiation of 728.3 W/m^2 (Figure 2). These results were acceptable, as the temperature needed to pasteurize the bale of corn or wheat straw could be achieved with the solar oven. The minimum temperature needed for pasteurization was between 50°C and 55°C (Sánchez-Vázquez et al., 2007). These results indicate that this low-cost solar oven can reduce

[1]Jonathan Domínguez-Aldana, Student, Universidad Anáhuac, Querétaro, México; [2]Héctor E. Ruelas-Monroy, Student, Universidad Anáhuac, Querétaro, México; [3]Vania D. Hernández-Bello, Student, Universidad Anáhuac, Querétaro, México; [4]Juan C. González-Castillo, Student, Universidad Anáhuac, Querétaro, México; [5]Israel Ruiz-González, Professor, Universidad Anáhuac, Querétaro, México; [6]Leslye Paniagua-Sánchez, Asst. Professor, Universidad Anáhuac, Querétaro, México. Corresponding author: I. Ruíz-González, email: israel.ruizg@anahuac.mx.

energy requirements and costs associated with production of mushrooms in Mexico.

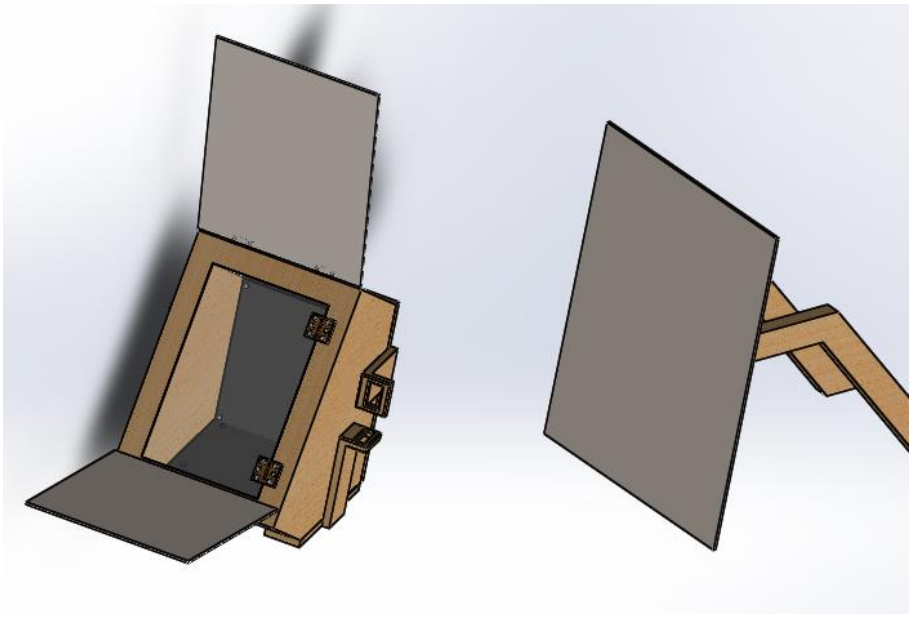

Figure 1. Model of the solar oven designed in SolidWorks.

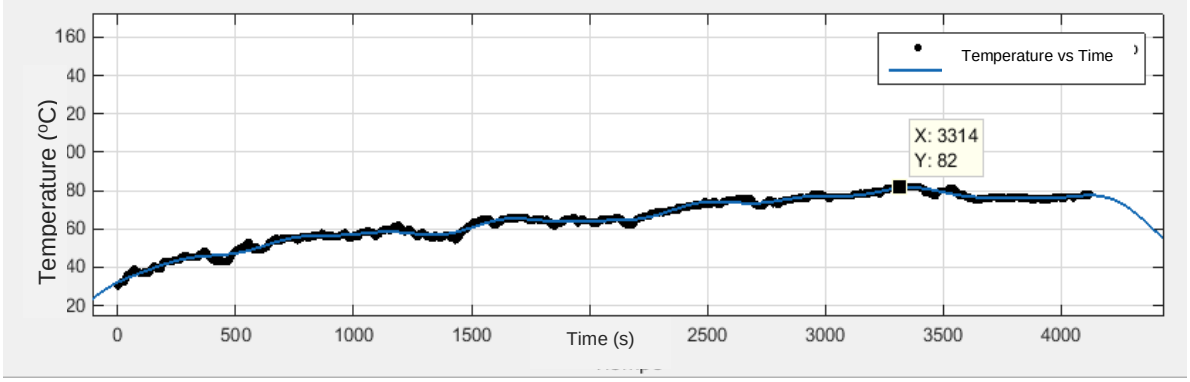

Figure 2. Temperature (ºC) versus time (s) inside the solar oven.

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